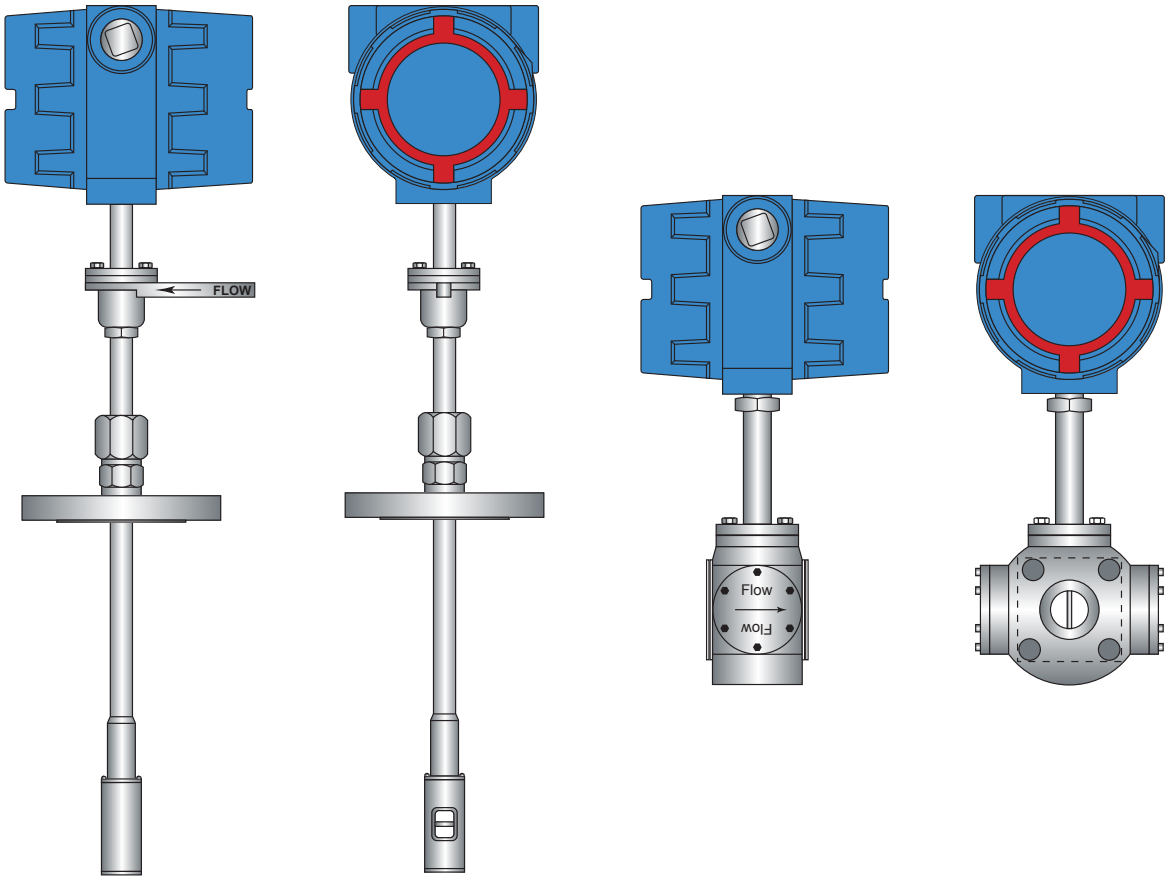
Vortex
Flow Meters

Intrinsically Safe Flow Meters

RWG/RWBG Wafer Style Flow Meters
RNG Insertion Style Flow Meters



Badger Meter

VRX-UM-00374-EN-03 (October 2014)

User Manual

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INTRODUCTION

The RNG/RWG/RWBG series vortex shedding flow meter family is designed to provide accurate and repeatable gas flow measurement. These meters employ a patented ultrasonic technique to measure a form of turbulence created in the flow stream. This turbulence, known as the Von Karman Vortex Street, is related to the flow through the pipe.

The RNG/RWG/RWBG series flow meter is a microprocessor based device, with HART compatible communications. The primary output of the meter is a 2 wire, 4…20 milliampere (mA) current which is proportional to the flow.

With HART communications, users have the capability to remotely configure the meter. Typical operations, like re-scaling the analog output, can be performed in comfort using a standard PC or HART 275/375 Communicator.

The wafer style meters are for pipe diameters four inches or less, and are installed between 150 lb flanges, or are manufactured with pipe extensions and 150 lb (300 lb optional) flanges welded on the ends. These meters are calibrated in volumetric flow units, that is Actual Cubic Feet per Minute (ACFM). Flow rates for the wafer style meters are listed in *Table 2* .

The insertion style meters are retractable meters that are installed through the walls of a pipe or duct larger than four inches. These meters can be installed through a 2 in. full port valve, which permits the unit to be retracted or inserted manually without shutting down the system. Flow rates for the Insertion style meters are shown in *Table 3*.

⚠DANGER

CAUTION SHOULD BE USED WHEN INSERTING OR RETRACTING AT PRESSURES EXCEEDING 60 PSIG (4.14 BARG).

SPECIFICATIONS

	Wafer	Insertion
Mounting Requirements	Mounts between two 150 lb. flanges	Options for 2 in. NPT, 2 in. 150# Flange, 2 in. 300# Flange, DN50 Flange
Operating Pressure	–5…250 psig (–0.34 …17 barg)	
Operating Temperature	–20…300° F (–28…150° C)	
Ambient Temperature	–20…155° F (–28…68° C)	
Accuracy	±1% of Reading over the upper 90% of the flow range	
Repeatability	0.5% of reading	
Input Power	28V DC Maximum	
Output	4…20 mA (2 wire)	

Table 1: Specifications

Flow Ranges

Gas / Air Application			
Flow Ranges for RWG / RWBG Series			
Model	**Pipe Size in. (mm)**	**Flow ACFM (m^3/hr)**	
		Minimum	**Maximum**
RWG05	0.5 (13)	0.4 (0.7)	16 (27)
RWG10	1 (25)	1.2 (2.0)	45 (77)
RWG15	1.5 (38)	2.0 (3.4)	100 (170)
RWG20	2 (50)	5.0 (8.5)	200 (340)
RWG30	3 (76)	10.0 (17.0)	400 (680)
RWG40	4 (102)	20.0 (34.0)	600 (1019)

Table 2: Flow Ranges for RWG / RWBG Series

Velocity Ranges

Gas / Air Application			
Velocity Range for RNG Series			
Model	**Pipe Size in. (mm)**	**Velocity fps (mps)**	
		Minimum	**Maximum**
RNG	4 (102)	2 (0.6)	140 (43)
	6 (152)		
	8 (203)		
	10 (254)		

Table 3: Velocity Ranges for RNG Series

Flow measured in feet / second @ 14.69 psia, 60° F (meter / second @ 1.013 bar, 16° C)

INSTALLATION

The flow meter is shipped completely assembled, tested and ready to install in its permanent location. See *Figure 2 on page 7* through *Figure 5 on page 10* for the applicable outline dimensions for specific meters.

Installation Location

The RNG/RWG/RWBG series meters uses ultrasonics to measure flow. An ultrasonic noise can interfere with this technique, therefore high intensity, ultrasonic noise sources should not be located upstream or downstream from the meter. Common mechanical ultrasonic noise sources include the following:

- Slightly cracked valves operating with large pressure drops.
- Small pipe leaks in high pressure systems.
- Venturies operating at near-sonic flow rates.
- Sonic nozzles.

If these ultrasonic noise sources cannot be eliminated, the meter should be mounted with at least one elbow between the flow meter and the noise source.

Mechanical Installation

The meter should be installed with at least 20 pipe diameters of straight pipe upstream and 10 pipe diameters downstream. This condition provides the fully developed, symmetrical flow profile that is necessary to obtain accurate and repeatable results. Shorter upstream/downstream piping may be used although a shift in calibration may occur. If severe turbulence or distorted flow profiles are present, flow straighteners should be used. See *"Additional Installation Requirements" on page 17* for additional information.

Meter Installation

The labeling of the flow direction on the meter should be aligned with the flow in the pipe. If liquids or condensate can be present in the flow, the meter should be installed so that liquids will not accumulate on the ultrasonic transducers (the small buttons on either side of the vortex strut).

The RWG/RWBG series **wafer** meters are designed to mount between two ANSI 150 lb flanges. The meter should be mounted so its inside diameter is centered inside the pipe. See *Figure 1*.

NOTE: Gaskets (not provided) are necessary between the sensor and the ANSI flanges. Ensure that these gaskets are properly installed and do not protrude into the flow stream.

⚠CAUTION

AVOID BENDING THE VORTEX STRUT OR DAMAGING THE TRANSDUCERS DURING INSTALLATION. DO NOT REMOVE COVER PLATES WHILE UNIT IS OPERATING.

The RNG series insertion meters are designed to mount on a standard ANSI 150 lb, 2" pipe flange. The measuring window should be installed in the center of the line for line sizes 12" or less (see *Figure 5 on page 10*). For line sizes larger than 12", the measuring window should be installed 25% to 50% of the way into the pipe. It is recommended that the internal dimensions of the line be measured for accurate readings.

Insertion meters can be used in any size pipe four inches and larger in diameter. In order to calculate accurate volumetric, mass, and standard flow measurements, it is recommended to enter the exact pipe size into the meter. Normally this operation, along with overall meter configuration, is performed at the factory. However, the user can enter the pipe diameter on site using the Racine HART Interface or a HART 275/375 communicator.

NOTE: The torque requirement for the Conax fitting is 90…100 ft-lb. See *Figure 5 on page 10.* See *"Additional Installation Requirements" on page 17* for additional installation information and flow profiling.

The RWGxxF series **flanged** meters are designed to mount between two ANSI 150 lb flanges (300 lb optional). See *Figure 4 on page 9*.

NOTE: Gaskets (not provided) are necessary between the ANSI flanges. Insure that these gaskets are properly installed and do not protrude into the flow stream.

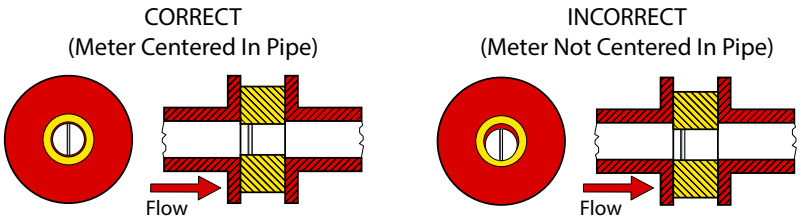


Figure 1: DXN Transducer connection diagram

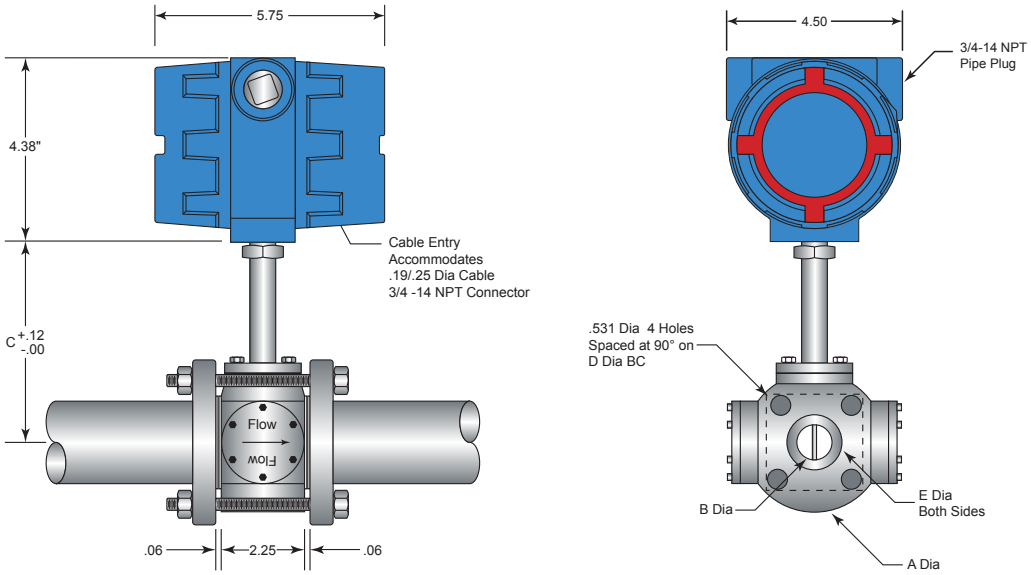


Figure 2: 1/2", 1" and 1-1/2" meters

Model	Diameter A in. (mm)	Diameter B in. (mm)	Dimension C in. (mm)	Dimension D in. (mm)	Dimension E in. (mm)
RWG/RWBG05	3.50 (89)	0.50 (13)	5.60 (142)	2.38 (61)	1.38 (35)
RWG/RWBG10	3.97 (101)	0.88 (22)	5.78 (147)	3.12 (79)	2.00 (51)
RWG/RWBG15	4.72 (120)	1.38 (35)	6.34 (161)	3.88 (99)	2.88 (73)

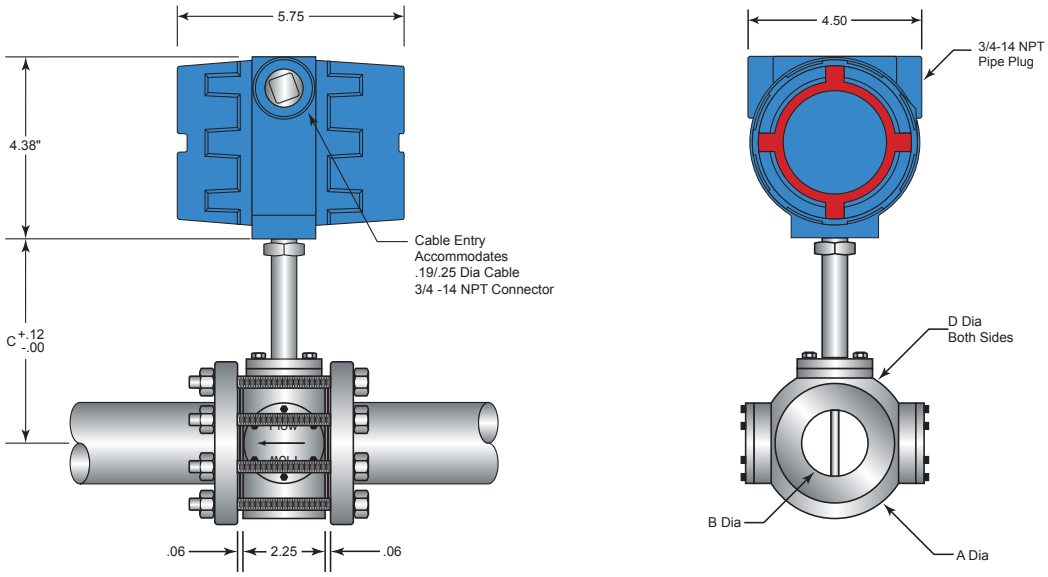


Figure 3: 2", 3" and 4" meters

Model	Diameter A in. (mm)	Diameter B in. (mm)	Dimension C in. (mm)	Dimension D in. (mm)
RWG/RWBG20	3.97 (101)	1.75 (45)	5.92 (150)	3.15 (80)
RWG/RWBG30	5.22 (133)	2.75 (70)	6.62 (168)	4.55 (116)
RWG/RWBG40	6.87 (174)	3.75 (95)	7.52 (191)	6.19 (157)

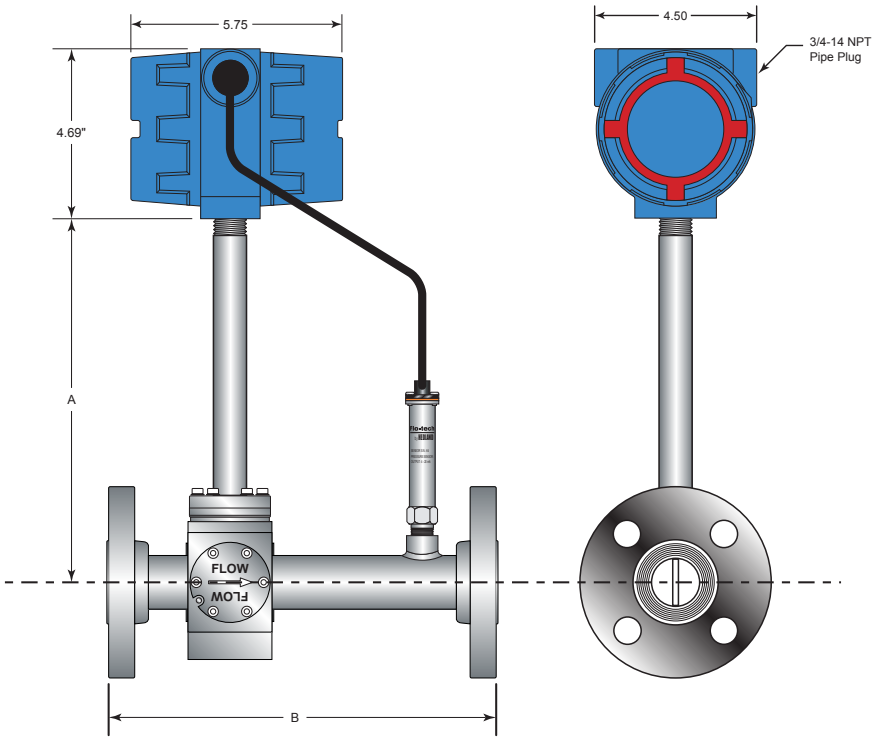


Figure 4: Outline dimensions for flanged series meters

Model	Size	Dimension B in. (mm)	Dimension A in. (mm)
RWG05F15*	1/2"	9.88…10.00 (250…254)	5.60 (142)
RWG10F15*	1"	9.88…10.00 (250…254)	5.78 (147)
RWG15F15*	1-12"	9.88…10.00 (250…254)	6.34 (161)
RWG20F15*	2"	9.88…10.00 (250…254)	5.92 (150)
RWG30F15*	3"	11.88…12.00 (301…304)	6.62 (168)
RWG40F15*	4"	11.88…12.00 (301…304)	7.52 (191)

*150 lb RF ANSI Flange, 300 lb RF ANSI Flange optional

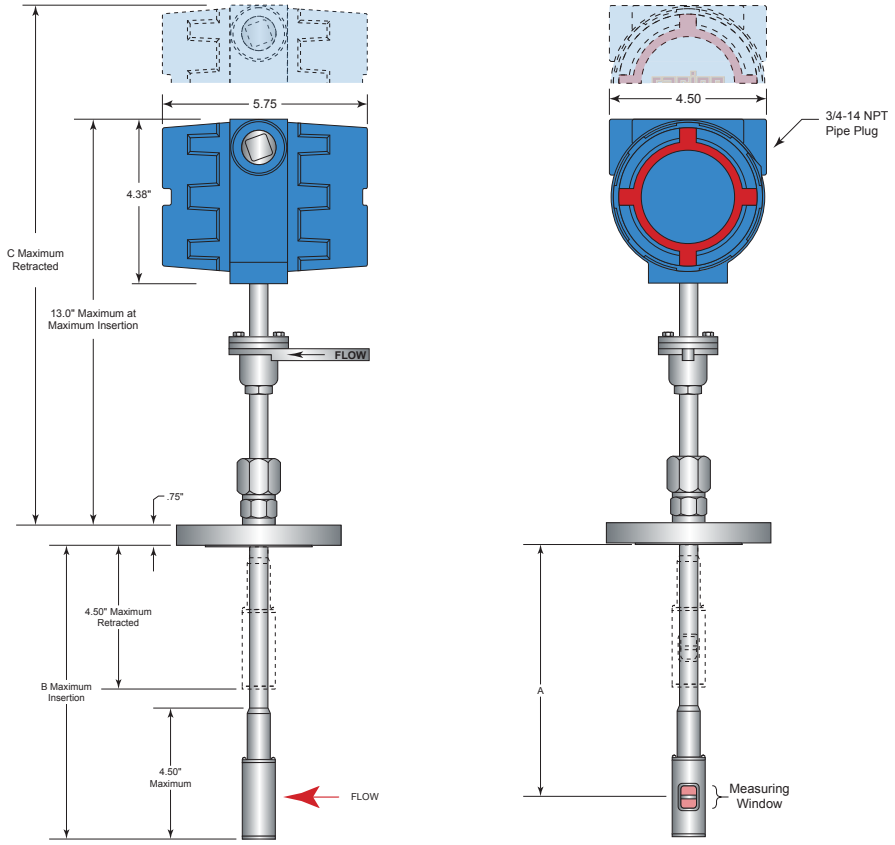


Figure 5: Outline dimensions for RNG insertion meters

Model	Dimension A in. (mm)	Dimension B in. (mm)	Dimension C in. (mm)
RNG12	12.00 (305)	12.88 (327)	21.50 (546)
RNG24	24.00 (609)	24.88 (632)	33.50 (851)
RNG36	36.00 (914)	36.88 (937)	45.50 (1156)
RNG48	48.00 (1218)	48.88 (1242)	57.50 (1461)
RNG60	60.00 (1524)	60.88 (1546)	69.50 (1765)

ELECTRICAL INSTALLATION

Electrical connections for the meter are made using screw terminals located inside the enclosure. To access these terminals, remove the lid from the enclosure. The functions of these terminals are illustrated in Figure 7.

To install the cable, route it through the cable entry located on either side of the enclosure and attach the wires to the appropriate terminals.

EMC NOTIFICATION

The ultrasonic sensing technology employes a 160 kHz carrier frequency and the flow meter is sensitive to radiated and conducted noise at or near this frequency. Precautions must be taken not to subject the flow meter or associated cabling to sources of RF noise that could interfere with the ultrasonic carrier. Any such interference can cause degradation in flow meter performance.

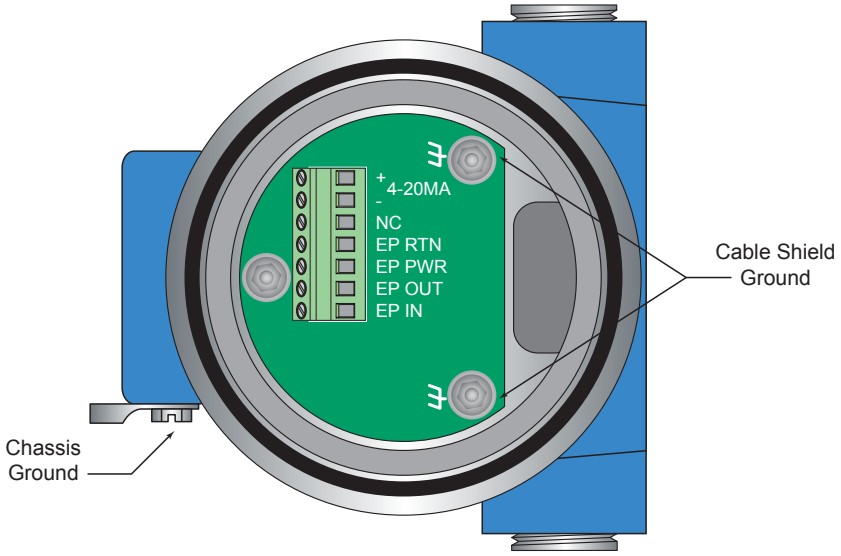


Figure 6: Flow meter terminal functions

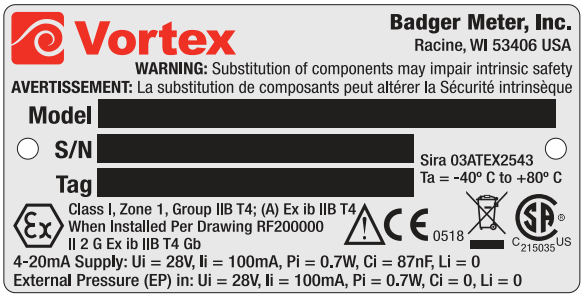
Terminal Designator	Function
4-20 mA +	Loop Power (+28 VDC maximum)
4-20 mA –	Loop Power (–)
NC	Not Used
EP RTN	Pressure Sensor Power Supply Return
EP PWR	Pressure Sensor Power
EP OUT	Power Out to Pressure Sensor
EP IN	Pressure Sensor Input

INSTRUCTIONS SPECIFIC TO HAZARDOUS AREA INSTALLATIONS

(Reference European ATEX Directive 94/9/EC, ANNEX II, 1.0.6)

The following instructions apply to equipment covered by certificate number SIRA 03ATEX2543.

1. The certification marking is as follows:


Vortex
Badger Meter, Inc.
Racine, WI 53406 USA
WARNING: Substitution of components may impair intrinsic safety
AVERTISSEMENT: La substitution de composants peut altérer la Sécurité intrinsèque
Model
S/N
Tag
Sira 03ATEX2543
Ta = -40° C to +80° C
Class I, Zone 1, Group IIB T4; (A) Ex ib IIB T4
When Installed Per Drawing RF200000
II 2 G Ex ib IIB T4 Gb
0518
4-20mA Supply: Ui = 28V, Ii = 100mA, Pi = 0.7W, Ci = 87nF, Li = 0
External Pressure (EP) in: Ui = 28V, Ii = 100mA, Pi = 0.7W, Ci = 0, Li = 0

2. The equipment may be used in zones 1 and 2 only with flammable gases and vapors with apparatus groups IIA and IIB and with temperature classes T1, T2, T3 and T4. It is not suitable for zones where IIC gases or vapors may be present.
3. The equipment is only certified for use in ambient temperatures in the range –40° F (–40° C) to +176° F (+80° C) and should not be used outside this range.
4. The equipment has not been assessed as a safety related device (as referred to by Directive 94/9/EC ANNEX II, Clause 1.5).
5. Installation, inspection and maintenance of this equipment shall be carried out by suitably trained personnel in accordance with the manufacturer's instructions and the applicable codes of practice (e.g., EN 60079-14 and EN 60079-17 in Europe).
6. Only spare parts supplied by Badger Meter may be used and installed in accordance with Badger Meter instructions.

WIRING

A two conductor foil shielded cable made of 14…22 AWG solid or stranded wire is required to make connections to the flow meter (for example, Consolidated Wire P/N 5573-CL).

The shield is required to be attached to one of the shield ground points as illustrated in *Figure 6 on page 11*. The other end of the shield should not be grounded.

When using the Zener Diode Barrier the maximum load resistance for the power depends on the supply voltage (see *Figure 7 on page 14*).

If a Barrier/Isolator is being installed, refer to the Barrier/Isolator manufacturers data sheet for maximum resistive loading on the output. (Excitation voltage input to meter must be 15V DC minimum when output is at 20 mA)

The flow meter requires a minimum of 15V DC at the meter's 4…20 mA (+) and (–) terminals to operate. With all loop loads installed in the loop, the voltage at the meter must be at least 15V DC or the meter will operate erratically if at all. The maximum load resistance for the meter depends on the supply voltage. The higher the supply voltage the greater the loop load the meter will support.

The current sense resistor used in HART communications should be installed only for setup or troubleshooting as the current sense resistor is an unnecessary loop load when the meter is operating under normal conditions.

NOTE: Current loops with large loads may work satisfactorily at low loop current outputs but cease to function as the output current increases. The reason for this is that as the current increases the voltage drop across the sum of the loop loads will increase in direct proportion to the current output. At some current output unique to that particular loop the voltage drop across the sum of the loop loads will leave less than the minimum 15V DC required at the meters input terminals.

If this occurs the loop load must be reduced enough so that at the maximum current output for the system the voltage at the meters power input terminals remains at least 15V DC

The external pressure sensor is limited to a 5 foot (1.5 meter) cable length.

Various wiring configurations are shown in *Figure 7 on page 14* and *Figure 8 on page 15*.

OPERATION

Power Terminals

The 4…20 mA terminals (+ and –) are used for the flow meter's power supply.

Current Output

The current output is accessed through the 4…20 mA + and – terminal loop and provides an output current proportional to the flow measured by the meter. This output is a standard 4…20 mA output, where 4 mA corresponds to no flow and 20 mA indicates 100 percent (full scale) flow. The current output will not be accurate if the load resistance on the current output terminal is too high.

Load Table for Flow Indicator or Control System Using Zener Diode Barrier		
Power Supply Voltage	24 V	26 V
Maximum Voltage Drop	3 V	5 V
Maximum Resistances	136 Ω	225 Ω
For Loads Greater Than 225 Ω, see Optional Wiring Diagram		
Figure D - Load TABLE		

Table 4: Load table

Barriers and Barrier Isolator Examples	
Stahl	9001/01-280-100-101 Zener Barrier
Turck	MK33-221-Ex0-HL/24V DC (2 Channel)
Turck	MK33-111-Ex-HLi/24V DC (1 Channel)

Table 5: Barriers and isolator examples

HART Communication

The Racine vortex meter has the capability of HART Communication. However, it is not required that it be used. In most cases, the meter is configured at the factory per the customer's specifications. The user need only install the meter and connect power.

If HART Communication is desired a current sense resistor must be placed in series within the current loop.

The value of the resistor can range from 170…600 Ω and be rated at 0.25 watt or larger. The placement of the resistor is illustrated in the wiring diagrams. The resistor will add to the total loop resistance and will raise the value of the required power supply voltage if it remains in the loop.

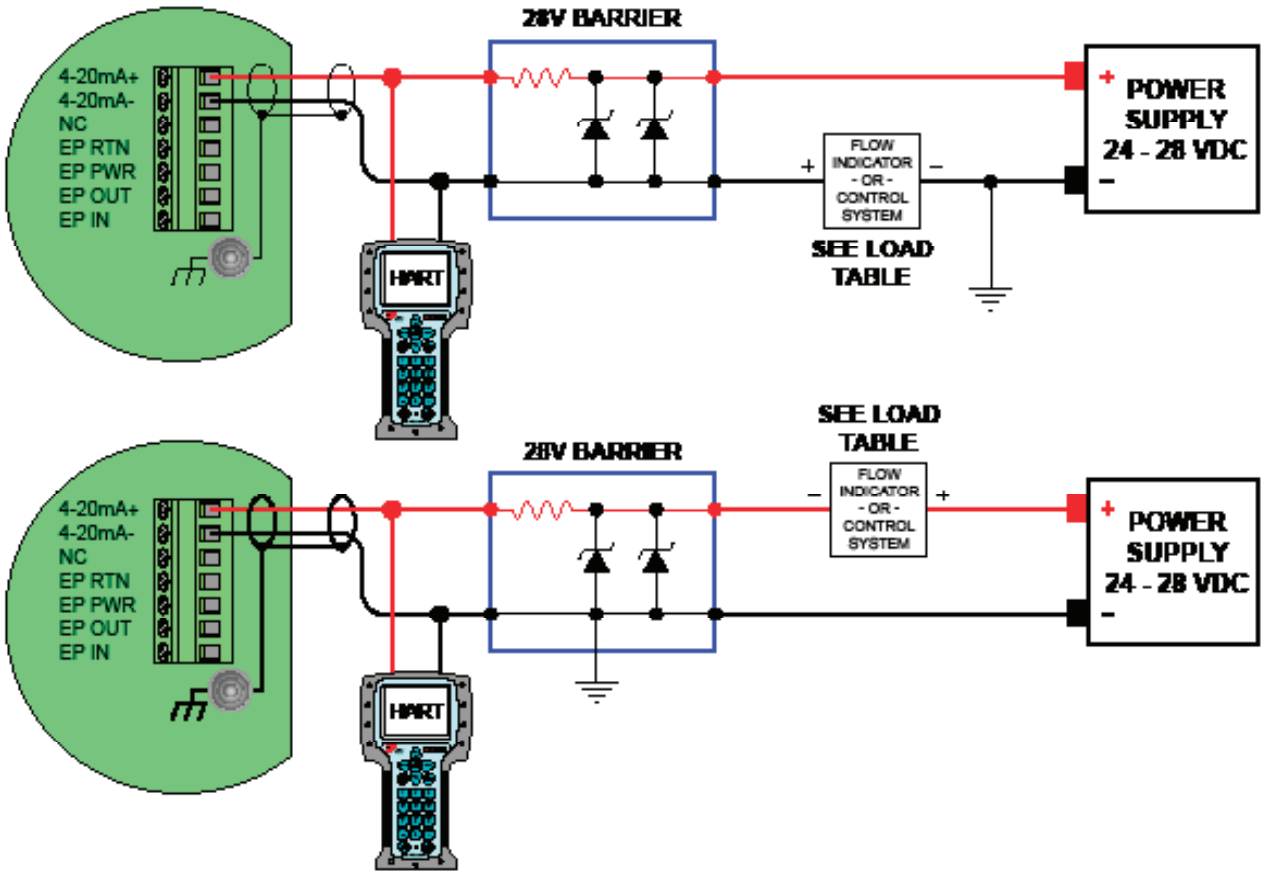
There are two ways to communicate to the meter via the HART interface: the Badger Meter HART Interface or a HART Communicator. The Badger Meter HART Interface is a PC-based software program that runs on Windows® 98, Windows NT, Windows ME, Windows XP, Windows Vista® and Windows 7 operating systems.

The HART 275/375 Communicator is a handheld device that can communicate with any HART device that is registered with the HART Communication Foundation. The HART 275/375 Communicator also provides access to all settings that can be configured by the user. The 275 provides a menu driven interface. See Figure 10 to view the menu map for the HART 275 Communicator.

NOTE: HART 275 Communicator requires Badger Meter drivers for proper communications. (See communicator owner's manual for driver listing).

WIRING DIAGRAMS

The wiring diagrams illustrated below are for installations where no 4…20 mA pressure sensor is used.



Optional wiring diagram for loads > 225Ω

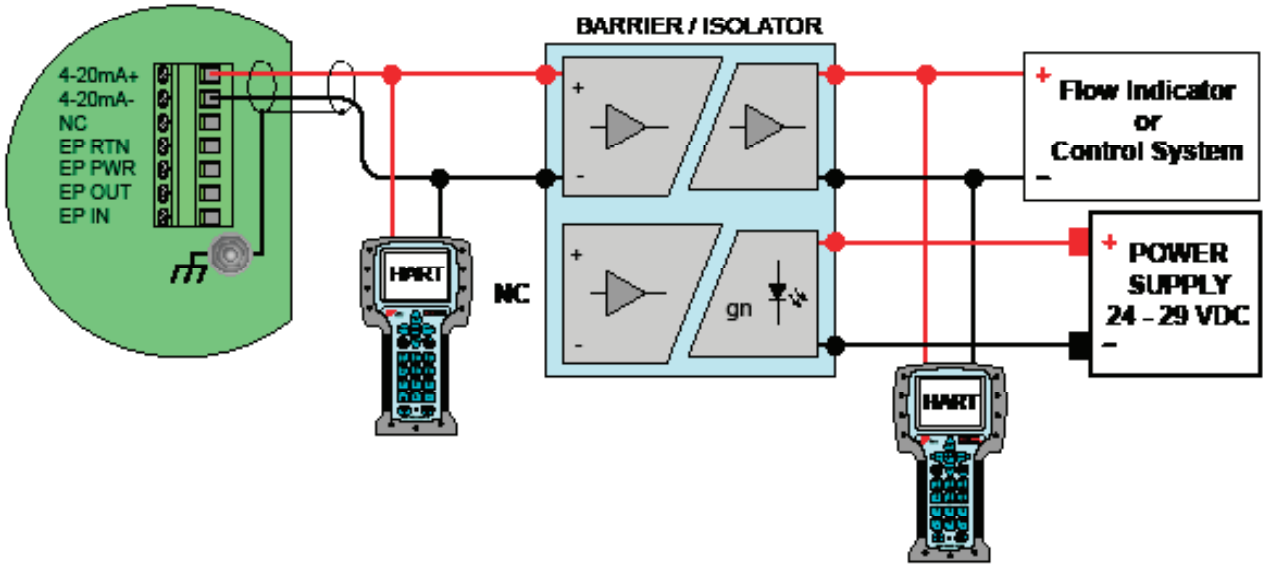
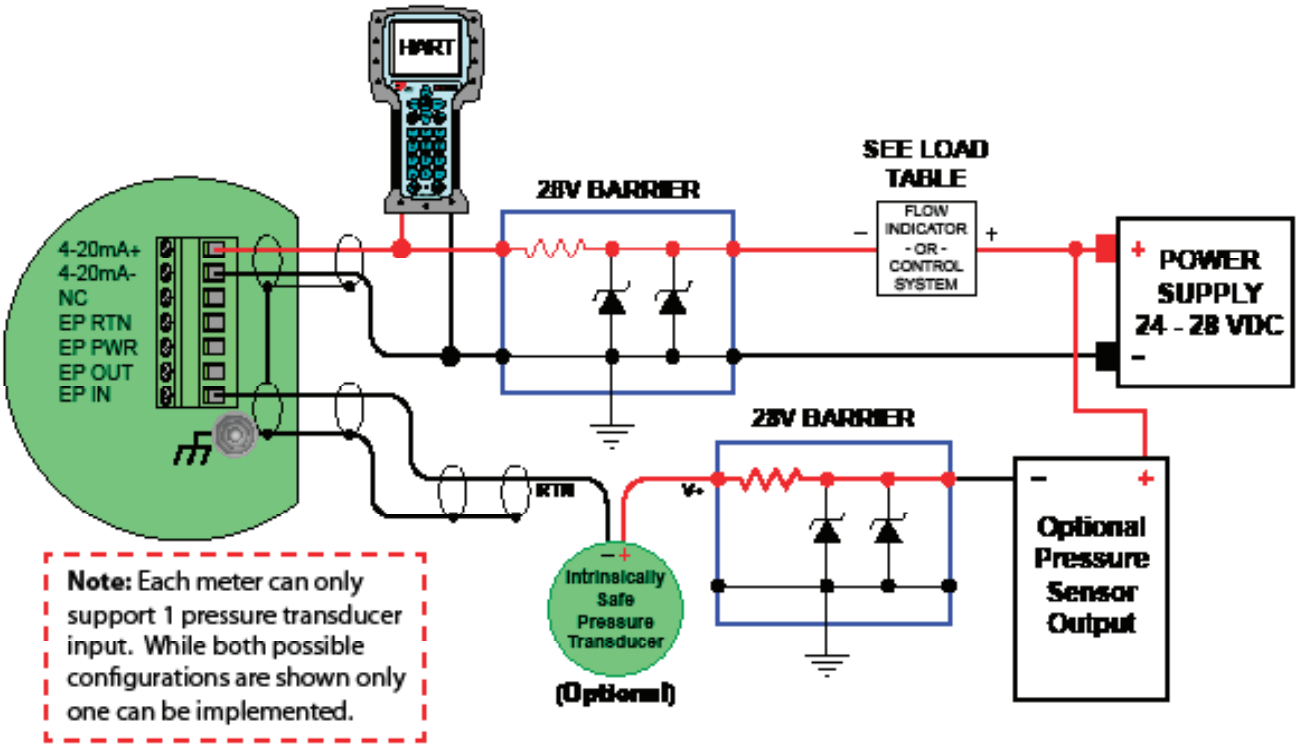


Figure 7: Without 4…20 mA output pressure transducer

If an analog pressure gauge is used, it must be wired as shown below to avoid inadvertent current paths.

A single supply can be used to power the flow meter and the external pressure sensor. The 4…20 mA flow indication must be taken from the source side of the loop.



Optional wiring diagram for loads > 225Ω

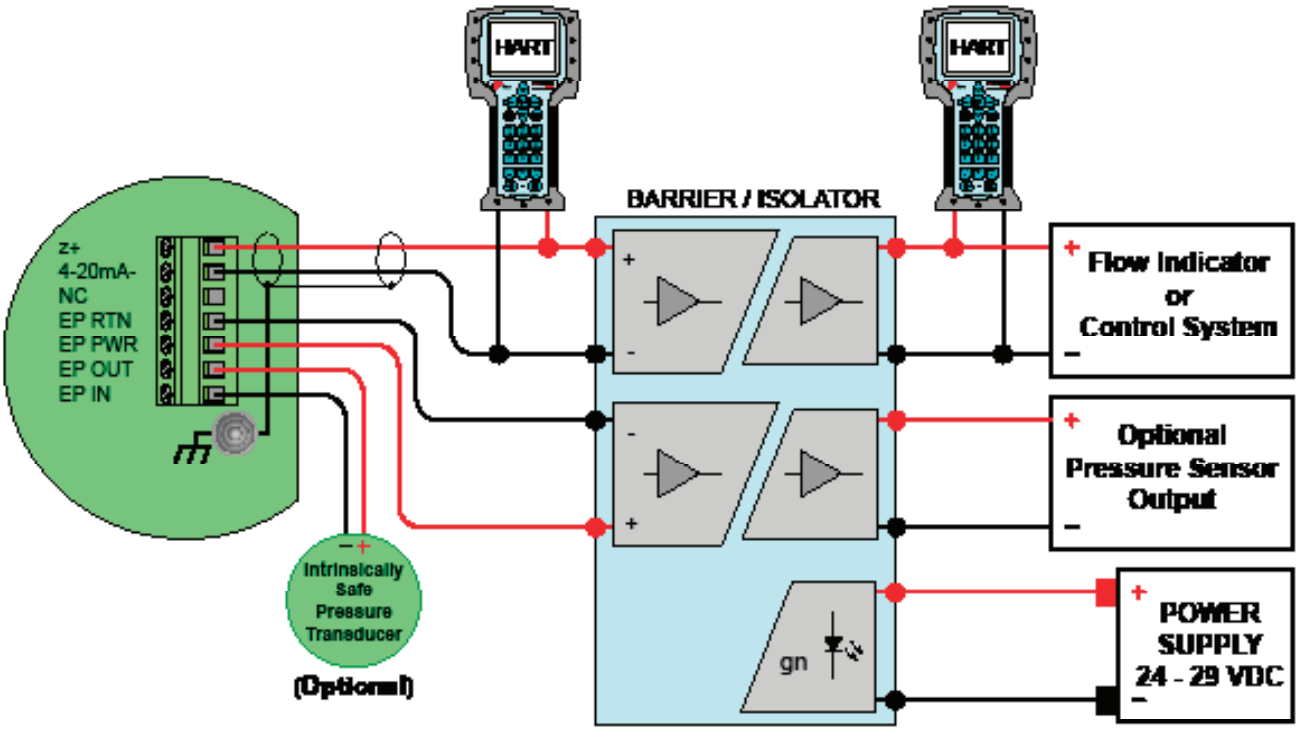


Figure 8: With 4…20 mA output pressure transducer

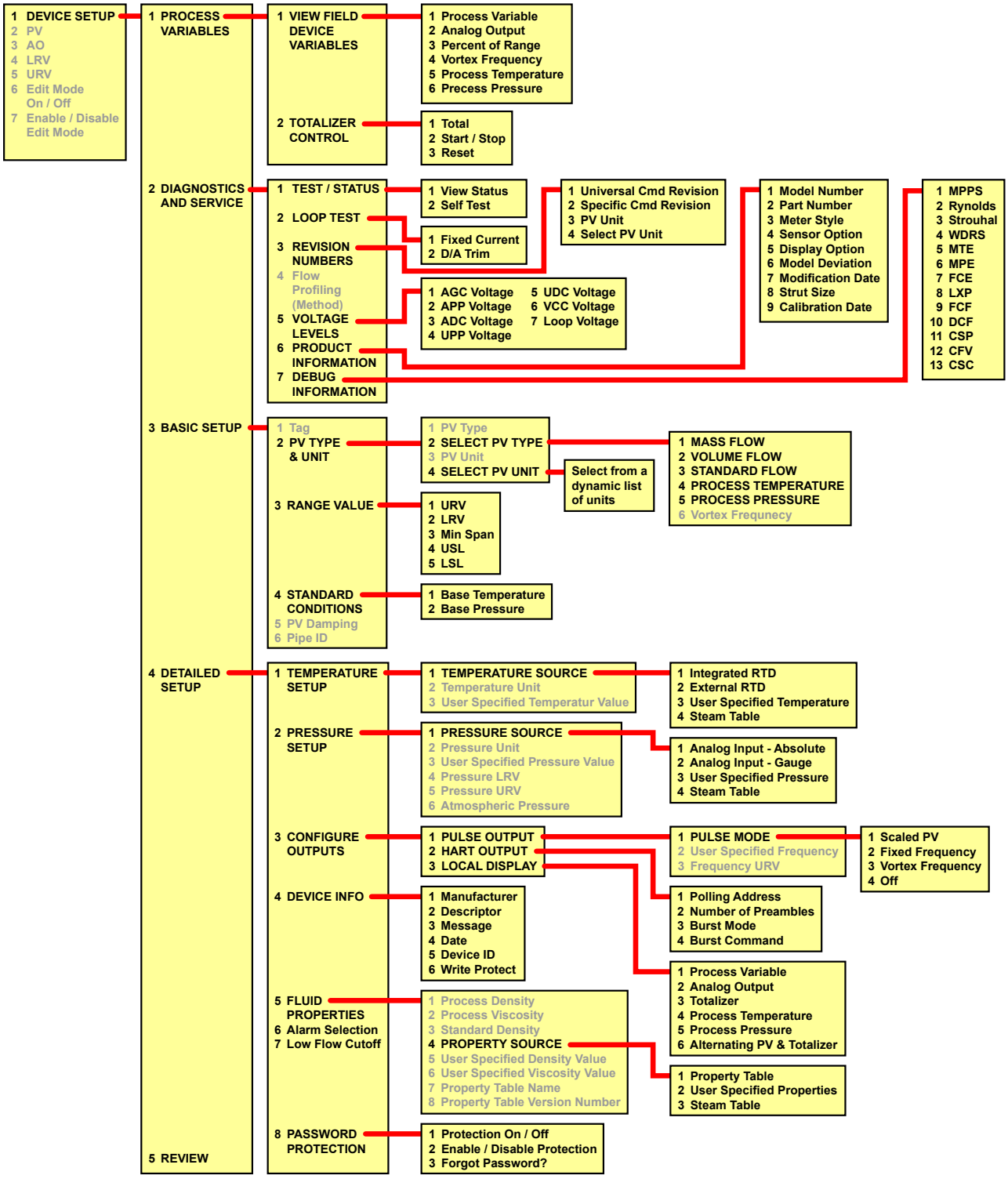


Figure 9: HART communicator menu tree v4.0

TROUBLESHOOTING

Racine vortex flow meters are designed to ensure long term accuracy and reliability. The stainless steel body and self-cleaning strut are specifically designed to withstand the rigors of industrial environments. As a result, periodic adjustment or re-calibration is not normally required. Technical assistance is also available directly from Racine Vortex, providing complete re-calibration and repair service for the flow meter at a reasonable cost.

Preliminary Checks

⚠DANGER

DO NOT OPEN ENCLOSURE IN HAZARDOUS AREAS WITH POWER APPLIED.

- Is the flow meter cable installed correctly?
- Is the proper power supplied to the proper terminals?
- Is the flow meter wired for 2 wire 4…20 mA operation.
- Is the shield tied to the shield ground terminal and only the shield ground terminal?

ADDITIONAL INSTALLATION REQUIREMENTS

Introduction

Installing a flow meter is something which requires careful consideration. It cannot just be placed in a line somewhere and be expected to fulfill its purpose adequately. The geometry and condition of the pipe runs in the area of the installation must be considered to ensure the best and most accurate operation of the flow-meter. This appendix provides suggestions for optimum installations.

Most flow meter manufacturers define installation conditions in terms of upstream and downstream straight pipe lengths from the point of installation. Unfortunately this is not the only requirement, and one needs to consider other peripheral conditions, such as proximity and style of bends, and other equipment installed in the line. By doing this, you avoid problems of turbulence, swirl, and sonic noise.

Turbulence

Turbulence is a disturbance of the flow caused by bends and obstructions in the flow stream (it is this phenomena which makes the vortex flow meter work). Fortunately turbulence dies out fairly quickly, so by positioning the flow meter well away from bends and obstructions this potential problem of measuring flow in turbulent conditions is overcome (see *Figure 11*).

Swirl

Unlike turbulence, swirl will not die away. Once created it will continue until dissipated on the next pipe bend in the system. Swirl occurs after two bends, in close proximity, which are at an angle to each other. When designing an installation, keep the flow meter out of any line which has two adjacent bends upstream (see *Figure 12*).

Sonic Noise

Sonic noise is created by valves (either flow control or pressure control valves) which are slightly open. Like swirl, sonic noise will only dissipate on a bend so it is important to install flow meters out of the line of sight of valves. Sonic noise is caused by liquid attaining sonic velocities through a slightly open valve that has a pressure difference across it. This noise travels both up and down stream from the valve so you have to ensure that the flow meter is installed well away from the valve, preferably around a bend (see *Figure 13*).

Velocity Profile

When using an RNG series insertion flow meter, it is necessary to consider the effects of the velocity profile across the pipe or duct to optimize accuracy.

In large pipes, the flow moves slowly at the pipe walls but is at maximum velocity in the center of the pipe creating a continuously variable velocity across the pipe (see *Figure 10*). This velocity variation is called the velocity profile of the pipe, and can be measured and plotted by using the insertion flow meter to measure velocities at various noted positions across the pipe. As the maximum velocity is in the center of the pipe, it follows that if the flow meter is positioned in the center, it will not measure average flow. The rule-of-thumb position is 25% of the way into the pipe, but the optimum position can only be obtained by measuring the profile and working out the correct position from that.

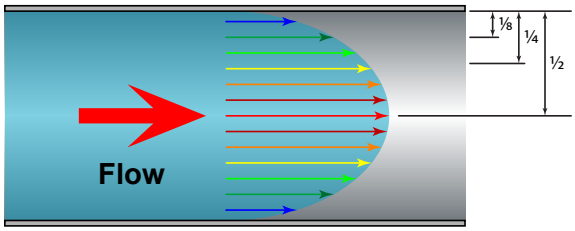


Figure 10: Typical velocity profile

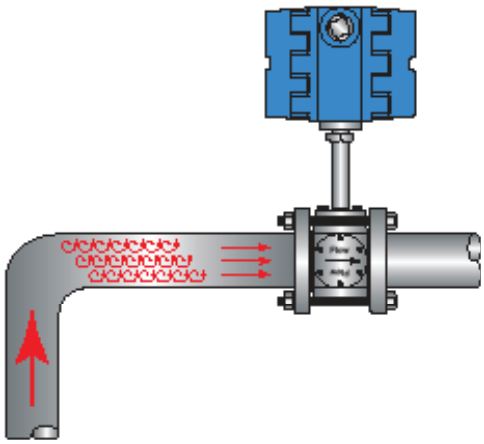


Figure 11: Turbulence caused by bend or obstruction

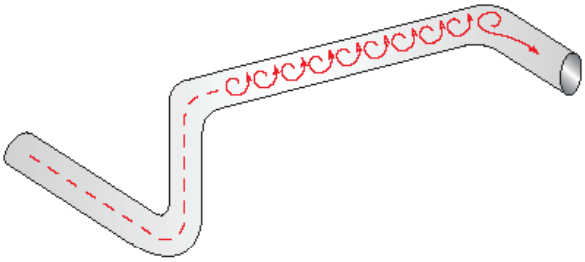


Figure 12: Swirl caused by two bends in different planes and in close proximity to one another

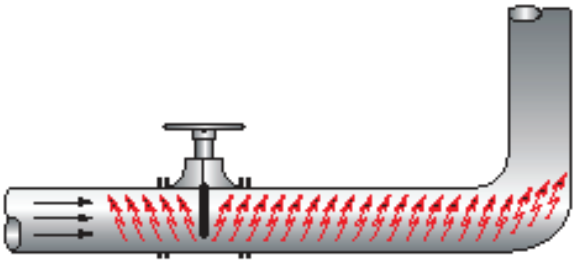


Figure 13: Upstream/downstream sonic noise caused by slightly opened control valves

Straight-Run Piping Considerations

The sensor should be installed with 20 diameters, or more, of straight, unobstructed, full area pipe upstream of the flow meter installation and 10 diameters, or more, downstream. This condition provides the fully developed, symmetrical flow profile that is necessary to obtain accurate and repeatable results. The first obstruction up and downstream should be a full area elbow. If the minimum straight run is not possible, the general rule is to have 80% of the straight run upstream and 20% downstream from the flow meter installation.

High intensity ultrasonic noises should not be located upstream or downstream from the sensor. Common ultrasonic noise sources include the following:

- Slightly cracked valves operating with large pressure drops.
- Small pipe leaks in high pressure systems.
- Venturies operating at near-sonic flow rates.
- Sonic nozzles.

If these ultrasonic noise sources cannot be eliminated, the meter should be mounted with at least one elbow between the flow meter and the noise source.

Temperature and Pressure Tap Locations

User supplied pressure and temperature sensors should be mounted downstream from the flow meter. The pressure sensor should be approximately 3 to 5 pipe diameters and the temperature sensor approximately 4 to 8 pipe diameters downstream.

Wafer Style Sensor Installation

The flow meter is shipped completely assembled, tested and ready to install and operate in its permanent location. The RWG wafer style flow meters are designed to mount between two ANSI flanges. The flow meter should be mounted so its inside diameter is centered inside the pipe. The labeling of the flow direction of the flow meter should be aligned with the flow in the pipe.

NOTE: Gaskets (not provided) are necessary between the sensor and ANSI flange. It is recommended that the customer conduct a flow profile survey prior to installing flow meter.

Insertion Style Meter Installation

The flow meter is shipped completely assembled, tested and ready to install and operate in its permanent location.

If the main line can be depressurized easily, then a simple installation, consisting of a 2" (51 mm) nozzle and a standard ANSI 150 lb, 2" pipe flange may be used. This permits the shortest shaft length to be used, which keeps clearance space requirements for insertion and removal to a minimum.

NOTE: Gaskets (not provided) are necessary between the sensor and ANSI flange. It is recommended that the customer conduct a flow profile survey prior to installing flow meter.

⚠DANGER

CAUTION SHOULD BE USED WHEN INSERTING OR RETRACTING AT PRESSURES EXCEEDING 60 PSIG (4.14 BARG).

Hot Tap Insertion Flow meter Installation

Where de-pressurizing the line for flow meter maintenance is impossible or undesirable, the "hot tap" method of installation is used. This method involves inserting the flow meter through a 2" (51 mm) spool piece and a 2" (51 mm) full port valve and will require a longer shaft length as well as greater clearance space for removal and installation.

⚠DANGER

CAUTION SHOULD BE USED WHEN INSERTING OR RETRACTING AT PRESSURES EXCEEDING 60 PSIG (4.14 BARG).

Figure 14 shows a sample hot tap installation. With the exception of the spool piece, which must be a minimum of 4.5" (114.3 mm), all of the dimensions are suggestions only. Actual dimensions may vary depending on customer's own hot tap configuration.

To calculate the required insertion flow meters stem length:

- For pipe diameters less than or equal to 24" (609 mm): Calculate the distance from the center line of the pipe to the top of the flow meter mounting flange.
- For pipe diameters greater than 24" (609 mm): Calculate the distance from the top of the flow meter flange to a point 1/4 of the pipe diameter into the pipe.

When flow profiling is required, calculate the distance from the bottom of the pipe to the top of the flow meter mounting flange and subtract 2" (51 mm). Next round this distance up to the next largest 12" (305 mm) increment. This is the stem length that should be ordered.

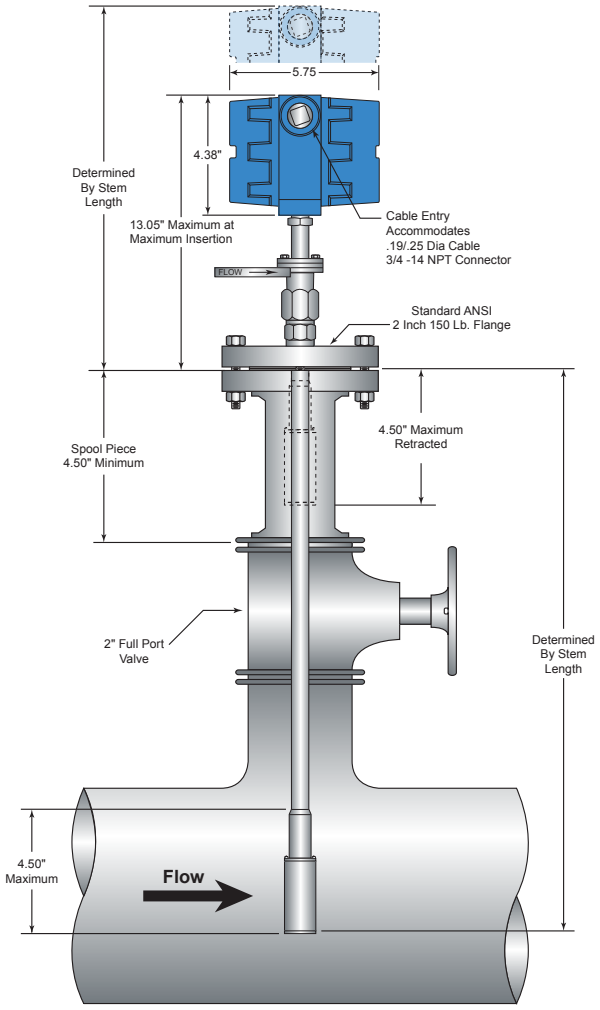


Figure 14: Hot tap configuration for RNG insertion gas meters

DANGER

CAUTION SHOULD BE USED WHEN INSERTING OR RETRACTING AT PRESSURES EXCEEDING 60 PSIG (4.14 BARG).

Flow Profiling

If the flow meter is long enough to be inserted to the far side of the pipe, the flow through the pipe may be profiled at various flow rates. The goal is to find a point in the pipe that remains a consistent percentage of the average flow rate over a wide range of flow. A sample flow profile is shown in *Table 6*. In this example, the flow rate of a 48" pipe is measured every six inches across the diameter of the pipe beginning and ending 3" from the near and far sides of the pipe. The distance in inches from the nearside of the pipe is shown. Measurements are taken at a low, medium and high average flow. In *Table 7*, the flow rate at each measurement point has been converted to a percentage of the average flow. It can be seen that point number three (15" from the near side of the pipe) reads a consistent 102 percent of the average flow. The meter should be placed in this position and the output should be divided by 1.02 to obtain the correct reading. Flow profiling will generally improve measurement quality in insertion meter installations.

Flow	**Flow Rate at Measurement Point (FPS)**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average (FPS)**
Low Flow	1.90	2.00	2.04	2.06	2.06	2.04	2.00	1.90	2.0
Medium Flow	5.58	5.91	6.12	6.21	6.24	6.18	6.06	5.70	6.0
High Flow	10.92	11.70	12.24	12.48	12.60	12.48	12.18	11.40	12.0
Distance (in)	**3**	**9**	**15**	**21**	**27**	**33**	**39**	**45**	

Table 6: Flow profile raw data

Flow	**Flow Rate at Measurement Point (%)**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Low Flow	95.0	100.0	102.0	103.0	103.0	102.0	100.0	95.0
Medium Flow	93.0	98.5	102.0	103.5	104.0	103.0	101.0	95.0
High Flow	91.0	97.5	102.0	104.0	105.0	104.0	101.5	95.0

Table 7: Flow profile normalized data

Reducing the Pipe Diameter

To decrease the variation of flow profile, the piping can be narrowed at the flow meter as shown in *Figure 15*. This will smooth the flow and increase the effectiveness of flow profiling. Nearly any angle can be used on the down-stream side of the meter to restore the original pipe diameter. However, if the angle of piping is seven degrees or less, nearly all the pressure drop caused by the narrow pipe section will be recovered.

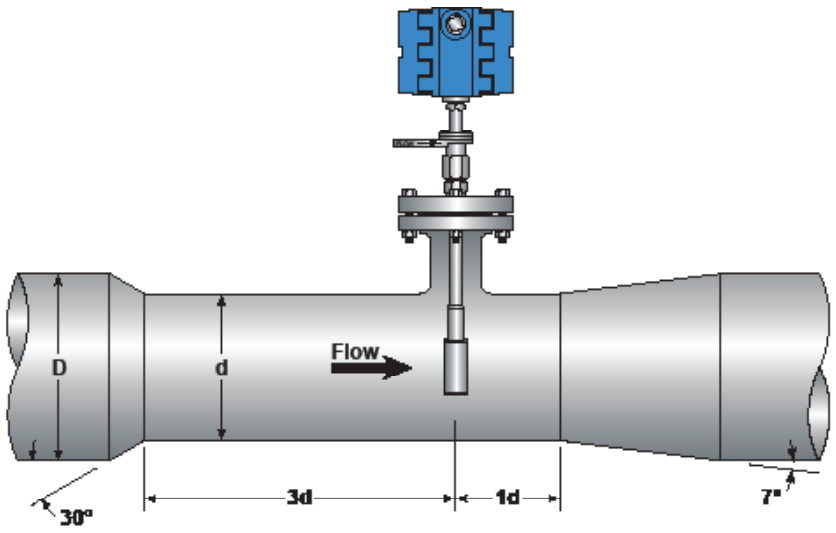


Figure 15: RNG insertion gas meter installed in a reduced pipe

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